CLAIMS

1. A three-dimensional liquid detection sensor comprising:

a three-dimensional (3D) liquid detection field; and,

a first electrical connector to supply a resistance measurement responsive to liquid in the detection field.

2. The sensor of claim 1 wherein the first electrical connector includes a first electrical contact and a second electrical contact.

3. The sensor of claim 2 wherein the first electrical connector is shaped to electrically connect and physically engage a first mating connector with a pair of electrical contacts.

4. The sensor of claim 2 wherein the sensor includes a second electrical connector with a pair of electrical contacts.

5. The sensor of claim 2 wherein the 3D liquid detection field includes:

a first plurality of pins having a distal end electrically connected to the first electrical contact; and,

a second plurality of pins having a distal end electrically connected to the second electrical contact.

6. The sensor of claim 5 wherein each pin has an axis aligned in a first plane.

7. The sensor of claim 5 wherein each pin has a right-angle shape.

8. The sensor of claim 5 wherein the first plurality of pins each have an axis aligned in a first plane; and,

wherein the second plurality of pins each have an axis aligned in a second plane, different from the first plane.

9. The sensor of claim 5 wherein a plurality of pins each includes a building material attachment barb attached to a pin proximal end.

10. The sensor of claim 5 wherein the detection field additionally includes:

a dielectric sheet;

a first electrically conductive trace formed overlying the dielectric sheet and connected to the first electrical contact;

a second electrically conductive trace formed overlying the dielectric sheet and connected to the second electrical contact;

wherein the first plurality of pins extend from the first trace; and,

wherein the second plurality of pins extend from the second trace.

11. The sensor of claim 5 wherein each pin has a cross-sectional axis diameter in the range of 0.01 to 0.3 inches.

12. The method of claim 5 wherein each pin has a length in the range of 0.25 to 5 inches.

13. The method of claim 5 wherein the detection field is a drywall interface and the length of each pin varies in the range of 0.375 to 0.5 inches.

14. The method of claim 5 wherein the detection field is an insulation interface and the length of each pin varies in the range of 1.5 to 5 inches.

15. The method of claim 5 wherein the detection field is a carpet interface and the length of each pin varies in the range of 0.25 to 0.375 inches.

16. The method of claim 5 wherein the separation between a pin from the first plurality of pins, and an adjacent pin from the second plurality of pins, is in the range of 0.1 to 2 inches.

17. The sensor of claim 10 wherein a plurality of pins are selectively detachable, at the distal end, from the electrically conductive traces.

18. The sensor of claim 10 wherein a plurality of pins each include:

an electrically insulated shoulder covering the distal end; and,

an electrically conductive proximal end.

19. The sensor of claim 10 wherein the dielectric sheet is rigid.

20. The sensor of claim 10 wherein the dielectric sheet is flexible.

21. The sensor of claim 10 wherein a plurality of pins each include a compressible spring connection between the distal end of the pin, and the electrical trace from which the pin extends.

22. The sensor of claim 2 wherein the first electrical connector includes spring-loaded jaws to capture a wire.

23. A system for detecting water leakage in a building, the system comprising:

a liquid detection field including:

a plurality of liquid detection sensors supplying an electrical resistance measurement responsive to detected moisture;

a plurality of cables for series-connecting the plurality of sensors and supplying a resistance sum;

a controller including:

a measurement circuit connected to the liquid detection field to accept the resistance sum, the measurement circuit comparing the resistance sum to a threshold resistance and supplying a control signal in response to the comparison; and,

an alarm circuit having an input to accept the control signal and an output to supply an alarm signal.

24. The system of claim 23 wherein the liquid detection sensors are selected from the group including three-dimensional (3D), two-dimensional (2D) flexible, liquid-sensitive building materials, and 2D rigid sensors.

25. The system of claim 24 wherein the 3D sensor includes a liquid detection interface with a plurality of pins for mounting in a building material selected from the group including carpet, padding, drywall, and ceiling tiles.

26 The system of claim 24 wherein the 2D flexible sensor includes a liquid detection interface with a pair of conductive traces overlying a first face of a flexible dielectric sheet for mounting around an object selected from the group including a pipe and a hose.

27. The system of claim 26 wherein the 2D flexible sensor includes a liquid detection interface with a pair of conductive traces overlying a first face of a flexible dielectric sheet and an adhesive attached to a second face of the flexible dielectric sheet.

28. The system of claim 24 wherein the 2D rigid sensor includes a liquid detection interface with a pair of conductive traces overlying a rigid dielectric sheet for mounting on a building surface selected from the group including a hardwood floor, a tile floor, concrete floor, and a baseboard.

29. The system of claim 23 wherein each cable is a wire-pair; and,

wherein the liquid detection sensors include spring-loaded jaw electrical connectors to capture the cable wires.

30. The system of claim 23 wherein the alarm sends an alarm signal selected from the group including an audio signal, a visual signal, a hard-wired telephone signal, a cell telephone signal, and a wireless signal.

31. A system for detecting water leakage in a building, the system comprising:

a liquid detection field including:

a plurality of connected liquid detection sensors including a first sensor type and a second sensor type, different

than the first sensor type, each sensor supplying an electrical resistance measurement responsive to detected moisture;

a plurality of cables for connecting the plurality of sensors and supplying a resistance sum;

a controller including:

a measurement circuit connected to the liquid detection field to accept the resistance sum, the measurement circuit comparing the resistance sum to a threshold resistance and supplying a control signal in response to the comparison; and,

an alarm circuit having an input to accept the control signal and an output to supply an alarm.

32. The system of claim 31 wherein the liquid detection sensors are selected from the group including three-dimensional (3D), two-dimensional (2D) flexible, liquid-sensitive building materials, and 2D rigid sensors.

33. A system for detecting water leakage in a building, the system comprising:

a plurality of independently powered liquid detection sensors with a controller interface, each sensor measuring an electrical resistance responsive to detected moisture;

a controller including:

a decision unit having a sensor interface to accept communications from the sensors and an output to supply a control signal; and,

an alarm circuit having an input to accept the control signal and an output to supply an alarm signal.

34. The system of claim 33 wherein the sensors communicate resistance measurements via the controller interface; and,

wherein the controller decision unit includes a measurement circuit to accept resistance measurements from the sensors, the measurement circuit comparing the resistance measurements to a threshold resistance and supplying the control signal in response to the comparison.

35. The system of claim 34 wherein the measurement circuit sums the resistance measurements and compares the resistance sum to a threshold.

36. The system of claim 33 wherein each sensor compares the measured resistance to a threshold, and sends a detection message via the controller interface in response to the comparison; and,

wherein the controller decision unit accepts detection messages and supplies the control signal in response to receiving detection signals.

37. The system of claim 33 wherein the sensor controller interface is an interface selected from the group including ac power line-coupled transmitter and a radio frequency (RF) transmitter.

38. The system of claim 33 wherein the liquid detection sensors are selected from the group including three-dimensional (3D), two-dimensional (2D) flexible, liquid-sensitive building material, and 2D rigid sensors.

39. The system of claim 33 the independently powered liquid detection sensors each have a power interface selected from the group including ac, dc, solar, and dc battery backup power.

40. A liquid-sensitive building material comprising:

a building material with a surface; and,

a liquid detection sensor, formed from a conductor, overlying the building material surface.

41. The building material of claim 40 wherein the building material is selected from the group including plywood sheets, pipes, tar paper, and insulation.

42. The building material of claim 41 wherein the building material further includes a sheet of porous material overlying the liquid detection sensor on the building material surface.

43. The building material of claim 40 wherein the liquid detection sensor includes a pair of conductive ink traces on the building material surface having an electrical resistance that is responsive to liquid between the traces.

44. The building material of claim 40 further comprising:

an adhesive sheet attached to the building material surface; and,

wherein the liquid detection sensor is formed on the adhesive sheet.

45. The building material of claim 43 further comprising:

an electrically conductive adhesive connector for bridging discontinuities in the sensor conductor on the building material surface.

46. The building material of claim 45 wherein the adhesive connector bridges between sensor conductors on adjoining building material surfaces.

47. The building material of claim 40 wherein the building material is insulation with a sheet of backing material; and,

wherein the liquid detection sensor is formed overlying the insulation backing sheet.

48. The building material of claim 40 wherein the building material is a plywood sheet having a plurality of overlying bonded wood layers; and,

wherein the liquid detection sensor is formed interposed between bonded layers of the plywood sheet.

49. The building material of claim 43 further comprising:

a detachable protecting coating overlying the sensor on the building material surface.

50. The building material of claim 40 wherein the building material is a pipe with an exterior surface; and,

wherein the liquid detection sensor is formed overlying the pipe exterior surface.

51. The building material of claim 40 wherein the liquid detection sensor includes a pair of conductors on opposite sides of the building material, having an electrical resistance that is responsive to liquid between the conductors.

52. In a building, a method for forming a leak detection system from leak-sensitive building materials, the method comprising:

providing leak-sensitive building materials;

electrically connecting the leak-sensitive building materials;

forming a liquid detection field from the electrically connected leak-sensitive building materials; and,

in response to detecting liquid in the liquid detection field, generating an alarm signal.

53. The method of claim 52 wherein forming a liquid detection field includes interfacing the electrically connected leak-sensitive building materials to a controller; and,

wherein generating an alarm signal includes generating an alarm signal in response to measuring a low electrical resistance in the liquid detection field.

54. The method of claim 53 wherein interfacing the connected leak-sensitive building materials to a controller includes using an interface selected from the group including radio frequency (RF), ac powerline, and hardwired connections.

55. The method of claim 52 wherein providing leak-sensitive building materials includes providing a liquid detection sensor, formed from a conductor, overlying a building material surface.

56. The method of claim 55 wherein providing a liquid detection sensor, formed from a conductor, overlying a building material surface, includes provided a liquid detection sensor formed from conductive ink.

57. The method of claim 52 wherein providing leak-sensitive building materials includes:

providing a building material with a surface; and,

adhesively attaching a porous sheet, including a liquid detection sensor, overlying the building material surface.

58. In a building, a method for detecting water leakage, the method comprising:

providing a plurality of independently powered liquid detection sensors;

measuring electrical resistance responsive to detected moisture;

interfacing the sensors to a controller; and,

using the controller to generate an alarm signal is response to receiving communications from the sensors.

59. The method of claim 58 wherein interfacing the sensors to a controller includes sending resistance measurements from each sensor to the controller.

60. The method of claim 58 wherein measuring electrical resistance responsive to detected moisture includes each sensor:

measuring an resistance; and,

comparing the measured resistance to a threshold; and,

wherein interfacing the sensors to a controller includes each sensor sending a detection message to the controller if the resistance exceeds the threshold.

61. The method of claim 58 wherein interfacing the sensors to a controller includes using an interface selected from the group including ac powerline and radio frequency (RF) signaling.

62. A three-dimensional (3D) water detection method comprising:

forming a 3D water detection field in a material; and,

supplying an electrical resistance responsive to liquid in the material.